Catalogue no. 63F0002XIE — No. 46
ISSN: 1481-6466
ISBN: 0-662-35246-7

Research Paper

Analytical Paper Series — Service Industries Division

Research and development in Canada's service sector

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December 2003

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Aussi disponible en français

Published by the authority of the Minister responsible for
Statistics Canada

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Abstract

Services constitute the single most important industry in Canada's economy, with 68% of total gross domestic product, 75% of employment and 53% of consumer spending. However, this industry is not widely perceived as being Canada's spearhead of research and development (R&D), a role more traditionally assigned to the manufacturing sector. Still, services are becoming an increasingly important force in research and development, which is why we should reconsider the true role played by research and development in the service sector. This article, in fact, sets out to quantify research and development activities within the service sector.

Here are some highlights of this exploratory study:

- In 2002, the commercial service sector[1] was responsible for 28.5% of all research and developme..t expenditures for the economy as a whole.
- In 2000, 36.6% of all full time personnel to research and development worked in the commercial service sector.
- R&D is primarily performed in such sectors as biotechnology, software, telecommunications, the environment and logistics. The sectors are not necessarily industries as recognised by the North American Industry Classification System (NAICS); in many cases they are activities spread across several industries.
- Several service sector activities are very labour intensive and require highly skilled research and development workers. For example, of all employees performing R&D in the field of biotechnology, 23% hold doctorates or master's degrees.

1. Commercial services include: supply services (transportation, warehousing and trade), communications, finance, real estate, insurance and business services (information systems, consultation, scientific research, etc.).

Research and development in Canada's service sector[2]

By Julio Miguel Rosa and F.D. Gault[3]

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Introduction

The service sector is the dominant activity in the Canadian economy. Services account for 68% of total gross domestic product (GDP), 75% of total employment, 53% of consumer spending and 16% of total exports (Statistics Canada 2002a). One of the key developments for the service sector in the last 10 years has been the sharp growth in information and communications technology (ICT) activities.[4] Between 1997 and 2002, the real output of ICTs attributable to the service sector jumped from $24,487 million to $44,457 million, or 81%,[5] whereas ICT growth in the manufacturing sector was 55% (Statistics Canada 2002b). Many technology-intensive activities are in the service sector. ICTs are just one example. Others include biotechnology, environmental, health and logistics services.

All these services require a substantial level of specialized human resources support. Indeed, as we will see in section 5 of this paper, these services are highly knowledge-intensive; that is, they often require a highly specialized university or technical education. This characteristic gives the service sector some capacity to conduct research and development and produce radical innovations. These innovations are evident in the introduction of new or significantly improved products or processes.

To maintain or increase their market share, businesses operating in these leading-edge areas in particular need to engage in activities ranging from R&D to product quality improvement, and they must have a desire simply to acquire knowledge, without which they inevitably lose their competitive edge. More generally, R&D is a component of the innovation system, whose effective function accounts in part for the economic growth of countries like Canada.

2. The opinions expressed in this article are those of the authors and do not necessarily reflect the views of Statistics Canada.

3. We are very grateful to Frances Anderson and Antoine Rose of Science, Innovation and Electronic Information Division for their support and encouragement throughout the project. In particular, we would like to thank Michel Séverd and Richard Vincent of Service Industries Division and Louis-Marc Ducharme for their valuable comments.

4. NAICS codes for the ICT industry: Manufacturing: 333310-334110-334210-334220-334310-334410-334511-334512-335920. Services: 417310-417320-417910-511210-513220-513310-513320-513330-513340-513390-514191-514199-514210-541510-811210.

5. Gross domestic product at basic prices in chained 1997 dollars.

The traditional assumption is that R&D tends to be a feature of the manufacturing industries. Yet the service sector has an increasingly important role to play in the R&D field in Canada. This article provides a descriptive examination of R&D activity in Canada's service sector. In support of our argument, we will paint a general picture of R&D activity and how it has evolved between 1997 and 2002. We will pay particular attention to human resources engaged in R&D. We will also describe R&D in certain leading-edge growth activities such as biotechnology, information and communications technologies, and logistics, health and environmental services. Lastly, we will look at the issue of funding and control of R&D activities in Canada. It is worth noting that Jankowski (2001) has described the R&D situation in the U.S. service sector, providing in addition an international comparison based on OECD data.

1. Commercial services

The service sector generated 68% of GDP in 2000 (Statistics Canada 2002a). Public utilities, educational institutions, and health-care and governmental institutions accounted for 16%. The remainder is attributable to commercial services, with 51% of GDP. Table 1 provides a breakdown for commercial services by industry.

The finance and real estate industry accounted for a fairly high proportion of the commercial services GDP and represended 19.4% of total GDP. On the other hand, its contribution to the labour force was three times lower. The opposite was true in the business services and retail trade sectors, as their workforce made up 16.4% and 11.9% of the total, respectively, whereas their relative percentage in the GDP was 9.8% and 5.3%.

Table 1.
Percentage in GDP and labour force in the commercial services sector, by industry, 2000 (basic prices in chained 1997 dollars)

	GDP		LFS	
	$ Millions	Share %	Thousands of people	Share %
Distributive services	**148,179**	**15.8**	3,097.9	**20.8**
Transportation and storage	45,198	4.8	779.8	5.2
Wholesale trade	53,493	5.7	548.2	3.7
Retail trade	49,488	5.3	1,769.9	11.9
Producer services	**311,103**	**33.3**	**3,985.2**	**26.7**
Communications	38,527	4.1	665.5	4.5
Finance, insurance and real estate	180,944	19.4	867.0	5.8
Business services[6]	91,632	9.8	2,452.7	16.4
Other services	**20,818**	**2.3**	**695.8**	**4.7**
Total commercial services	**480,100**	**51.4**	**7,778.9**	**52.2**
Total other than commercial services	**453,613**	**48.6**	**7,130.8**	**47.8**
Total	**933,713**	**100.0**	**14,909.7**	**100.0**

Source: *Statistics Canada, (2002b), LFS: Labour Force Survey*

6. Business services comprises the following industries: Management, scientific and technical consulting; Computer systems design and related services; and Architecture, engineering and related Services. For further details, see Statistics Canada (2002c).

2. Share of GDP attributable to R&D by sector of performance and funding

In 2001, gross domestic expenditure on R&D (GERD) totalled $20,871 million at current prices. This represented 1.9% of GDP (Statistics Canada 2002d), up from 1.5% in 1990, representing a 26% increase for the decade.

We note that the GERD performance share of all sectors declined between 1998 and 2001, excepting for the share of higher education institutions, which increased during that same period (Table 2). This reverses what was observed in the 1993-1996 period, when performance share improved for the business sector and decreased for all other sectors (Gault 1998). Higher education institutions also significantly increased their funding share between 1998 and 2001, while other sectors either reduced their share or raised it very slightly. In fact, in recent years, higher education institutions have been increasing their share of R&D in the service sector.

Table 2.
Percentage of GERD by performance and funding sector, 1998, 2000 and 2001

	Government	Business	Higher education	Private non-profit	Foreign
			Percentage of 1998 GERD by sector		
R&D performed	12.2	59.6	27.1	1.1	
R&D financed	21.7	45.2	14.6	2.6	15.9
			Percentage of 2000 GERD by sector		
R&D performed	11.2	56.8	31.0	1.0	
R&D financed	22.7	42.5	16.4	2.6	15.8
			Percentage of 2001 GERD by sector		
R&D performed	10.6	55.8	32.7	0.9	
R&D financed	22.5	42.0	17.3	2.7	15.5

Source: *Statistics Canada (2001 Survey of Research and Development in Canadian Industry)*

3. Distribution of R&D in the service sector

R&D by service enterprises accounted for nearly 29% of total R&D in 2002. The business services industry account for 17.3% of the total on its own. Between 1998 and 2002, the business expenditures on research and development (BERD) grew by 35% in business services (see Table 3). The industry not only carries out the most R&D but also funds the most R&D.

Over the 1998-2002 period, the compound average annual growth rate for R&D expenditures in the commercial services sector was 3.8%, slightly lower than the rate for the rest of the economy. Within the sector, growth was particularly steady in the transportation and storage industry and the business services industry. The business services industry's strong performance was due in part to the meteoric rise of information and communications technologies (ICTs). We provide more details on this activity in section 6.4. The transportation and storage industry's growth is harder to account for, but one possible explanation is that in recent years, there has been a surge in logistics services that provide better planning and more efficient management of merchandise flows and inventories (see Bess and McKeown 1997). It is also worth noting that a small number of large companies conduct virtually all of the R&D in that industry.

Table 3.
R&D distribution and growth by service industry, in millions of dollars and percentage, 1998-2002

	1998		1999		2000		2001		2002		
Marketable services	**BERD**	**%**	**BERD**	**%**	**BERD**	**%**	**BERD**	**%**	**BERD**	**%**	**Average growth rate %**
Distributive services	**634**	**6.6**	**666**	**6.5**	**563**	**4.9**	**575**	**4.8**	**591**	**5.3**	**-1.4**
- Transportation and storage	23	0.2	25	0.2	32	0.3	35	0.3	34	0.3	10.8
- Wholesale trade	558	5.8	604	5.9	498	4.3	506	4.2	522	4.6	-1.1
- Retail trade	53	0.5	37	0.4	33	0.3	34	0.3	35	0.3	-8.8
Communications	**318**	**3.3**	**306**	**3.0**	**321**	**2.8**	**344**	**2.9**	**348**	**3.1**	**2.4**
Finance, insurances and real estate	**131**	**1.4**	**108**	**1.1**	**125**	**1.1**	**132**	**1.1**	**150**	**1.3**	**4.4**
Business services	**1,438**	**14.9**	**1,610**	**15.7**	**1,675**	**14.6**	**1,924**	**16.1**	**1,940**	**17.3**	**7.9**
- Computer systems design and related services	515	5.3	542	5.3	624	5.5	690	5.8	709	6.3	8.4
- Architecture, engineering and related services	363	3.8	406	4.0	398	3.5	526	4.4	499	4.4	9.2
- Management, scientific and technical consulting	35	0.4	40	0.4	39	0.3	38	0.3	39	0.3	3.0
- Scientific research and development, health care and social assistance	525	5.4	622	6.1	614	5.4	670	5.6	693	6.2	7.4
Other services	**241**	**2.5**	**212**	**2.1**	**177**	**1.5**	**175**	**1.5**	**174**	**1.5**	**-7.6**
Total commercial services	**2,763**	**28.6**	**2,900**	**28.4**	**2,862**	**25.0**	**3,149**	**26.3**	**3,202**	**28.5**	**3.8**
Total other than commercial services	**6,913**	**71.4**	**7,328**	**71.6**	**8,587**	**75.0**	**8,824**	**73.7**	**8,042**	**71.5**	**4.3**
Total BERD	**9,676**	**100.0**	**10,228**	**100.0**	**11,449**	**100.0**	**11,973**	**100.0**	**11,244**	**100.0**	

Source: *Statistics Canada (2001 Survey of Research and Development in Canadian Industry)*

4. Human resources engaged in research and development

The commercial services sector employs 37% of the total R&D workforce. Of that percentage, 64% are professionals, 27% are technicians, and the remaining 9% are split among the other categories (see Table 4 below).

The proportion of personnel engaged in R&D in the commercial services sector is quite comparable to the proportion in manufacturing (see Statistics Canada 2000c). The commercial services sector is becoming an increasingly heavy user of skilled labour. The relative percentage of R&D jobs is higher than the relative percentage of R&D expenditures (29%) in the sector. The use of new technologies is placing greater emphasis on knowledge and at the same time reducing the need for support staff.

In terms of growth, the number of R&D workers in commercial services grew at the same pace as the rest of the economy between 1997 and 2000. In general, the growth in R&D jobs followed the upward trend in R&D spending, but at a slower pace. The one exception was the finance, insurance and real estate industry, where higher R&D expenditures were accompanied by a sharp drop in the number of R&D jobs

Table 4.
Number of people engaged in R&D by occupational category in the commercial services sector, 2000

	Person-year	%
Professionals	**21,720**	**64.3**
Bachelor	18,083	83.2
Master's	2,258	10.4
Doctorate	1,379	6.4
Technicians	**9,140**	**27.1**
Other	**2,900**	**8.6**
Total services	**33,760**	**100.0**

Source *: Statistics Canada (2002 c)*

(see Table 5 below). It is quite possible that R&D expenditures in those industries went mainly to physical capital rather than human capital.

Appendix Table 7 shows the number of people engaged in R&D in 2000 for certain activities in the service sector. The table also provides the ratio of workers with doctoral and master's degrees engaged in R&D to the total R&D workforce. This ratio is an indicator of the level of knowledge being used in R&D for each type of activity.

The activities that employ full-time R&D workers are mostly those involved in software development, ICTs and biotechnology. However, the biotech and environmental activities have the largest proportions of employees with master's degrees and doctorates working on R&D, with 23% and 18%, respectively, of the total R&D workforce in their industry.

Table 5.
Number of people engaged in R&D by industry in the service sector, 1997-2000

Marketable services	1997		1998		1999		2000		Average growth rate %
	Person-year	%	Person-year	%	Person-year	%	Person-year	%	
Distributive services	**5,110**	**6.2**	**5,338**	**6.2**	**5,422**	**6.2**	**4,531**	**4.9**	**-3.5**
- Transportation and storage	242	0.3	192	0.2	254	0.3	351	0.4	16.6
- Wholesale trade	4,325	5.2	4,624	5.4	4,587	5.2	3,674	4.0	-4.6
- Retail trade	543	0.7	522	0.6	581	0.7	506	0.5	-1.8
Communications	**4,375**	**5.3**	**4,276**	**5.0**	**4,487**	**5.1**	**5,014**	**5.4**	**4.8**
Finance, insurances and real estate	**1,920**	**2.3**	**1,414**	**1.6**	**1163**	**1.3**	**1042**	**1.1**	**-18.2**
Business services	**16,296**	**19.7**	**18,551**	**21.6**	**19,938**	**22.7**	**21,130**	**22.9**	**9.1**
- Computer systems design and related services	7,075	8.6	8,131	9.5	8,827	10.0	9,718	10.5	11.2
- Architecture, engineering and related services	4,232	5.1	4,461	5.2	4,607	5.2	4,455	4.8	1.8
- Management, scientific and technical consulting	779	0.9	695	0.8	780	0.9	780	0.8	0.5
- Scientific research and development, health care and social assistance	4,210	5.1	5,264	6.1	5,724	6.5	6,177	6.7	13.9
Other services	**2,619**	**3.2**	**2,582**	**3.0**	**2,734**	**3.1**	**2,043**	**2.2**	**-6.9**
Total commercial services	**30,320**	**36.7**	**32,161**	**37.5**	**33,688**	**38.3**	**33,760**	**36.6**	**3.7**
Total other than commercial services	**52,406**	**63.3**	**53,690**	**62.5**	**54,158**	**61.7**	**58,521**	**63.4**	**3.8**
Total BERD	**82,726**	**100.0**	**85,851**	**100.0**	**87,846**	**100.0**	**92,281**	**100.0**	**3.7**

Source: *Statistics Canada (2001 Survey of Research and Development in Canadian Industry)*

5. Performance indicator for R&D expenditures

Table 3 does not contain the figures needed to compare the level of effort in terms of R&D spending per R&D worker. To make such a comparison between companies or at the aggregate industry level, we have to compute the ratio of R&D expenditures (Table 3) to the number of people working full time on R&D (Table 5). That ratio is an indicator of the performance of R&D spending (Table 6).

However, caution is advised, since the denominator includes professional, technical and unskilled personnel. For example, an industry with proportionally more unskilled workers and relatively little capital invested in R&D should have a low ratio. Conversely, an industry with proportionally more capital invested in R&D and proportionally more professional workers should have a high ratio. This may explain the performance of the distribution

services industry, which has proportionally fewer professional workers than unskilled workers, and the poor performance of management and scientific consulting services. Nevertheless, it is worth noting that between 1998 and 2000, the ratio in the finance industry rose sharply as a result of a decline in the denominator.

Table 6.
Ratio of R&D expenditures to people in R&D, 1998-2000

Marketable services	1998	1999	2000	Average growth rate
	$	$	$	%
Distributive services	**118.8**	**122.8**	**124.2**	**2.2**
- Transportation and storage	119.8	86.6	91.2	-11.2
- Wholesale trade	120.7	131.7	135.5	6.0
- Retail trade	101.5	63.7	65.2	-17.4
Communications	**74.4**	**68.2**	**64.0**	**-7.2**
Finance, insurance and real estate	**92.6**	**92.9**	**119.9**	**14.7**
Business services	**77.5**	**80.7**	**79.3**	**1.2**
- Computer systems design and related services	63.3	61.4	64.2	0.78
- Architecture, engineering and related services	81.4	88.1	89.3	4.8
- Management, scientific and technical consulting	50.3	51.3	50.0	-0.27
- Scientific research and development, health care and social assistance	99.7	108.7	99.4	0.24
Other services	**93.3**	**77.5**	**86.6**	**-2.6**
Total commercial services	**85.9**	**86.1**	**84.8**	**-0.64**
Total other than commercial services	**128.7**	**135.3**	**146.7**	**6.78**
Total BERD	**112.7**	**116.4**	**124.1**	**4.95**

Source: *Statistics Canada (2001 Survey of Research and Development in Canadian Industry)*

6. R&D in fast-growing service activities

R&D is part of the national innovation system, which includes R&D, inventions, technology innovation and dissemination, and the specialists involved in all these activities (Gault, 1998). R&D capability is also a characteristic of businesses that introduce world firsts through innovations of products and processes.

In the next few sections, we present a few highlights of R&D in selected growth activities in the service sector. The above-mentioned activities are not mutually exclusive. Some of them do not fit into an official classification, but all of them are of increasing interest to the scientific community and have a significant impact on activity in the service sector.

The statistics we present[7] are based on data from the 2001 Survey of Research and Development in Canadian Industry (RDCI).[8] In that survey, 7,896 companies reported conducting R&D activities in 2000, and 3,856 of them were in the service sector.

7. See appendix tables.
8. The 2002 statistics are preliminary.

6.1 Biotechnology R&D

Biotech activities are aimed at transforming processes, products and services, mostly in health care, agriculture (particularly agri-food) and natural resources.

Biotech is a growth area in terms of the amount spent on R&D. In 2000, biotech R&D activities accounted for 5.7% of total BERD.

According to Statistics Canada's R&D survey, nearly $649 million were spent on biotech R&D in 2000, compared with $425 million in 1997. Of the total for 2000, 66% was for biotech R&D activities in the service sector (column 2 over column 4, Appendix Table 4).

Biotechnology generates substantial intrasectoral trade since it also depends on computer and communications technologies. In other words, the growth in biotech activities can have a significant impact on many industries and, in particular, other leading-edge technologies.[9]

6.2 Environmental R&D

The RDCI survey collects data on R&D spending on prevention, processing and reuse of waste and pollutants and on energy use reduction. In this area, 329 companies reported R&D activities, and half of them (156) were in the service sector. This activity's R&D expenditures made up only 2.5% of total BERD in 2000, but only 12% of environmental R&D spending takes place in the service sector. This modest share of R&D spending is probably an understatement since it does not include R&D investment whose primary purpose is to improve production (Statistics Canada 1997e).

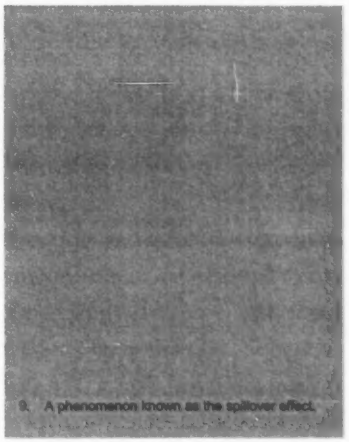
Pollution abatement and control is a socio-economic objective whose long-term benefits should offset the costs of not taking action today. The urgency of taking action accounts in part for the fact that environmental R&D activities are booming. Between 1997 and 2000, BERD in the service sector's environmental industries rose by 88%.

Public concerns about decontamination of polluted sites and the recent Kyoto accords, whose protocol Canada has ratified, are indicators that R&D expenditures in this area will continue to grow in the next few years.

6.3 Health R&D

R&D spending in the health-care part of the business services sector is estimated with data on the pharmaceutical products and drugs industry, the drug wholesaling industry, the health care and social services industry and selected firms in other industries (Statistics Canada 2002f).

The health sector has experienced generally steady growth in its share of gross expenditure on R&D (GERD) since 1988. That share climbed from 13.5% in 1988 to 20.5% in 2001. Expenditures totalled $4.2 billion, more than half of which (60%) was attributable to higher education. R&D in this industry is performed mainly by universities, hospitals,



9. A phenomenon known as the spillover effect.

government laboratories and non-profit institutions (Statistics Canada 2002f).

The aging of Canada's population has intensified the need for care of all types. New technologies must constantly be developed to improve diagnostic accuracy. Medical and diagnostic analysis laboratories are the most R&D-intensive. Over 60% of all R&D activity in the health care and social services industry is attributable to medical laboratories and diagnostic analysis centres (Statistics Canada 2002c).

6.4 The information and communications technology industries

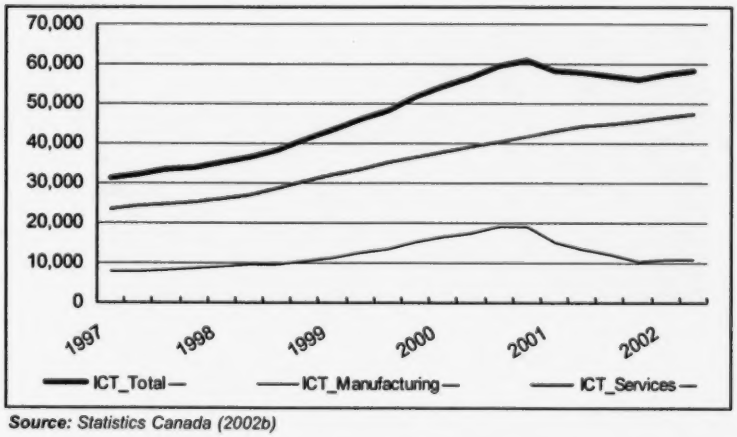
The information and communications technology (ICT) industries have probably contributed most to changes in the nature of activities in the service sector. Methods of producing and transmitting information in the sector have changed so much that economists now describe the current period as the era of the new economy. In the 1980s, people talked about the information society or telematics.

ICT activity is unevenly divided between manufacturing and services, the latter having the larger share. In 2001, services accounted for 69% of ICT GDP. Of that percentage, 64% is performed by the telecommunications industry, and 26% by the computer systems industry; the remainder is split among software publishers, cable services and other services (Statistics Canada 2002b).

Though very dynamic, ICT industries have suffered a few cyclical setbacks since the second half of 2000. Surprisingly, the downturn was entirely due to declines in the ICT manufacturing sector (see Chart 1 below).

The GDP of ICT in manufacturing peaked at $19,183 million in the third quarter of 2000, then slumped to $10,265 million in the fourth quarter of 2001, or by 46%. Over the same period, ICT in the service sector enjoyed an 11% increase in its GDP. The decline in ICTs essentially reflects the anaemic sales, at the wholesale level in particular, of broadcasting and communications equipment and telephone equipment. Between 2000 and 2001, GDP in those industries fell from $6,732 million to $3,349 million, while GDP in telecommunications services grew by 13% (Statistics Canada 2002b).

R&D activities are just as unevenly distributed in the ICTs. In 2002, the service sector accounted for only 21% of the R&D in ICTs. As well, as shown in Appendix Table 1, that share has been shrinking; it was 24% in 1997. However, R&D spending on ICTs by the service sector increased by 28% between 1997 and 2002.



Source: *Statistics Canada (2002b)*

Chart 1.
Distribution of ICT GDP by sector, 1997-2002

6.4.1 Telecommunications R&D

As indicated in the previous section, telecommunications leads by a wide margin in terms of share of ICT activity in the service sector. However, R&D spending in the telecommunications industry dropped by 28% between 1997 and 2002. The decline was largely due to a decrease in the number of R&D-performing companies from 48 to 28 during the period (see Appendix Table 3).

6.4.2 Software R&D

Informatics R&D is another important component of ICTs. Software development accounts for a very large proportion of those activities. A total of $3,581 million was spent on R&D in software development, 30% of it in the service sector. What is remarkable is the large number of companies performing R&D in this area; the number increased from 252 companies in 1997 to 1,135 in 2000 in services.

Software development is closely tied to other leading-edge areas. The communications, logistics, biotechnology and transportation industries are heavy users of those types of products and services.

7. Logistics services R&D[10]

"Logistics services activities strive to ensure an efficient flow of products through the supply chain" (Bess and McKeown, 1997). Though general, this definition indicates what type of activities logistics services are involved in: reducing shipping and warehouse management costs or improving the quality and timeliness of those services.

In recent years, R&D has surged in the industry, jumping 70% between 1997 and 2000 (see Appendix Table 6). The rapid growth of ICTs, deregulation of transportation in the 1990s, and the free trade agreement between Canada, the United States and Mexico have helped the logistics industries improve their services.

In 2002, R&D spending in logistics services was over $52 million, surpassing environmental R&D ($33 million in 2000) and nearly equalling telecommunications R&D ($57 million in 2002) (see appendix tables). The number of logistics companies conducting R&D has remained fairly stable since 1998, oscillating between 88 and 92. As shown in Appendix Table 7, 39 people with master's and doctoral degrees were working full-time on R&D in the logistics industries in 2000.

8. Who is funding R&D in Canada's service sector?

Nearly 31% of total R&D spending ($3,492 million) comes from foreign sources, compared with 2% from the federal government and 4% from other Canadian sources (Statistics Canada 2002f). However, R&D funding from foreign sources remains relatively weak in the service sector. Of the total amount of R&D funding from foreign sources, only 10%, or $364 million, goes to the service sector, compared with 89% to manufacturing (Statistics Canada 2002g).

10. The following NAICS codes were used to define logistics activities: 482112-482113-483115-483213-484110-484121-484122-484210-484221-484222-484223-484229-484231-484232-484233-484239-486110-486210-486910-486990-488320-488511-488519-491110-492210-493110-493120-493130-493190-541619-514191-514210.

9. Conclusion

This article has shown that R&D spending in the commercial services sector accounts for nearly one third of total R&D expenditure. We also found that the service sector is a heavy user of highly skilled R&D labour. The business services sector has a high proportion of university graduates. In addition, we noted the substantial R&D spending in certain fast-growing industries in the service sector. In those industries, information and communications technologies and biotechnology appeared to be important players in R&D, as indicated by the expenditures and number of jobs involved. Other less traditional service activities have been booming since 1997, notably environmental and logistics services. The structure and vigour of R&D in the service sector are evolving rapidly. Consequently, we recommend that future studies on the subject take into consideration the irregularities in the structure of R&D in the services sector.

While the service sector dominates Canada's economy, we are not yet able to grasp all the effects that the new industries are having on the economic structure and the organizational changes they involve. R&D is one of the indicators that will help us understand those changes. R&D growth provides us with useful information about the direction that the new technologies in the services sector may take. However, we still need to put considerable effort into understanding how knowledge is transferred in the services sector. Our approach, which provides statistics on economic activities not covered by an official industry classification, shows that understanding technology and innovation does not depend directly on any such type of classification, but rather on a need for information about an evolving economy. To that end, we should simply keep in mind that R&D and innovation are activities and not industries and that they cannot be adequately captured by the current industrial classification system (NAICS).

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Appendix

Table 1.
R&D expenditures in millions of dollars for information and communications technologies activities by sector

Years	Services		Manufacturing		Total	
2002	1,097	(1,447)	4,068	(596)	5,165	(2,043)
2001	1,074	(1,447)	4,895	(597)	5,969	(2,044)
2000	983	(1,449)	4,747	(598)	5,730	(2047)
1999	901	(1,669)	3,446	(704)	4,347	(2373)
1998	899	(1,698)	3,232	(737)	4,131	(2435)
1997	858	(1,669)	2,697	(733)	3,555	(2402)

Note: Number of companies performing R&D in parentheses.

Table 2.
R&D expenditures in millions of dollars for software activities by sector

Years	Services		Manufacturing		Total	
2002	-		-		-	
2001	-		-		-	
2000	1,068	(1,135)	2,513	(260)	3,581	(1,395)
1999	917	(1,019)	1,896	(260)	2,813	(1,279)
1998	821	(430)	1,839	(204)	2,660	(634)
1997	828	(252)	1,508	(192)	2,336	(444)

Note: Number of companies performing R&D in parentheses.

Table 3.
R&D expenditures in millions of dollars for telecommunications activities by sector

Years	Services		Manufacturing	Total	
2002	57	(28)	-	57	(28)
2001	57	(29)	-	57	(29)
2000	55	(29)	-	55	(29)
1999	66	(35)	-	66	(35)
1998	88	(38)	-	88	(38)
1997	80	(48)	-	80	(48)

Note: Number of companies performing R&D in parentheses.

Table 4.
R&D expenditures in millions of dollars for biotechnology activities by sector

Years	Services		Manufacturing		Total	
2002	-		-		-	
2001	-		-		-	
2000	427	(197)	222	(115)	649	(312)
1999	449	(166)	184	(97)	633	(263)
1998	395	(79)	166	(58)	561	(137)
1997	278	(54)	147	(43)	425	(97)

Note: Number of companies performing R&D in parentheses.

Table 5.
R&D expenditures in millions of dollars for environmental activities by sector

Years	Services		Manufacturing		Total	
2002	-		-		-	
2001	-		-		-	
2000	33	(156)	249	(173)	282	(329)
1999	31	(131)	193	(156)	224	(287)
1998	21	(58)	156	(108)	177	(166)
1997	18	(33)	101	(83)	119	(116)

Note: Number of companies performing R&D in parentheses.

Table 6.
R&D expenditures in millions of dollars for logistics activities

Years	Services		Manufacturing	Total	
2002	52	(88)	-	52	(88)
2001	53	(89)	-	53	(89)
2000	49	(89)	-	49	(89)
1999	35	(92)	-	35	(92)
1998	41	(91)	-	41	(91)
1997	31	(71)	-	31	(71)

Note: Number of companies performing R&D in parentheses.

Table 7.
R&D knowledge intensity in the services, by industry, 2000

Activity	Number of people with master's and doctorat	Total number of people engaged in R&D	Ratio ((doctorates + master's) / total)
Biotechnology	961	4,097	23.5
Software	1,936	17,465	11.1
Environment	236	1,290	18.3
Telecommunications	32	590	5.4
ICTs	1,263	15,429	8.2
Logistics	39	634	6.2

Source: *Statistics Canada (2001 Survey of Research and Development in Canadian Industry)*

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